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American
POTATO JOURNAL

Volume 37 *May 1960* *Number 5*

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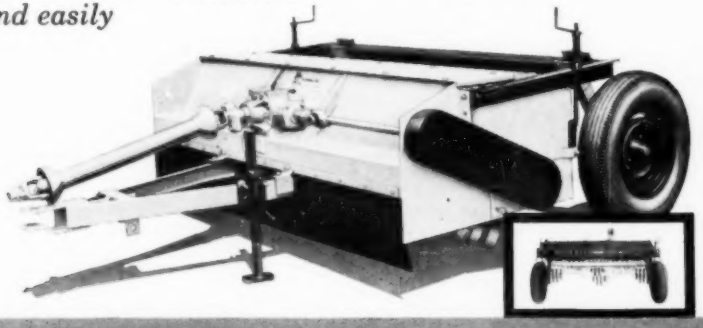

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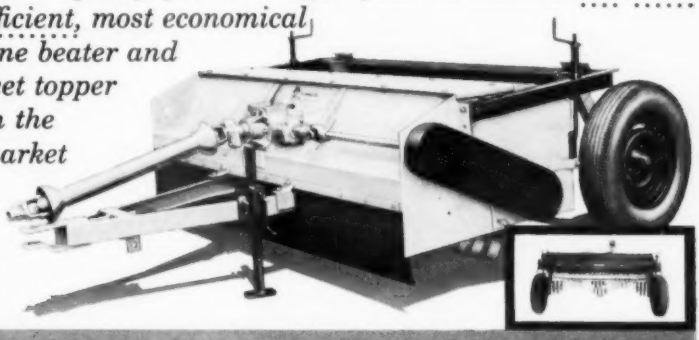

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Entered as second class matter at New Brunswick, N. J., March 14, 1942 under Act of March 3, 1879. Accepted for mailing at special rate of postage provided for in section 412, Act of February 28, 1925, authorized on March 14, 1928.

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TYPES OF POTATO VIRUS Y NECROTIC TO TOBACCO: HISTORY AND RECENT OBSERVATION[1]

KARL M. SILBERSCHMIDT[2]

Prof. Klinkowski who preceded me on this program, was one of the first to study and to describe exhaustively the strain of potato virus Y that causes a very destructive disease of tobacco in Germany, the so-called "Tabakrippenbräune" and also, as was later shown, a severe disease of the potato. If we thus may consider Prof. Klinkowski as one of the "fathers" of the necrotic strains of potato virus Y, without too much exaggeration I may flatter myself to be one of the "grandfathers" of the strain.

My claim to this title is based upon the fact that in 1941 I isolated, in cooperation with my pupil Nelson Ramos Nobrega, a strain of potato virus Y necrotic to tobacco. It was isolated from the Peruvian potato variety Serrana Negra which probably belongs to *Solanum andigenum*. This means that our isolation was made 11 years before the first trace of that disease was observed in Germany. Later, on several occasions, we found other similar strains harbored for the greater part by potato tubers received from countries occupying the central tableland or the Pacific side of South America.

Since these strains have acquired a new importance, with the epidemical rise of "Tabakrippenbräune" in Central Europe, I shall outline here, in chronological order, some of the results obtained in Brazil before the disease appeared and became epidemic in Central Europe. In these brief remarks we shall first sum up our observations on each strain and then allude to eventual discrepancies between our results and those obtained by others. We shall start the characterization of our strains of potato virus Y by describing the symptoms which our Serrana Negra strain, isolated in 1941, induces in young plants of White Burley tobacco. About 10 days after sap inoculation of a medium leaf, the young leaves display a very pronounced vein necrosis which extends even to the tertiary veins and sometimes to areas between these veins. These symptoms have caused us to name the disease "necros das nervuras" or "vein necrosis." In some cases the necroses are so severe that the attacked leaves die within a short time; in other cases the leaf borders dry out and the whitish, necrotic areas cause a rolling-in of the leaf blade. The leaves which mature some time after the inoculation of the tobacco plant display necrotic symptoms only on the apical part of the leaf blade; however, these leaves with limited areas of vein necrosis, which are formed in the chronic stage of the disease, show in addition a faint mosaic and vein banding. We think that the symptoms observed by us in these early studies agree with those of "Tabakrippenbräune" of the modern days.

Although we used tobacco as an indicator species, *Nicotiana tabacum* was by no means the only species displaying symptoms of the vein necrosis disease. We shall, however, refrain from presenting here the results of

[1]Accepted for publication October 23, 1959.
Invitational paper, presented at the 43rd Annual Meeting of The Potato Association of America, University of New Brunswick, Fredericton, N. B., Canada, August 1959.
[2]Instituto Biológico, Sao Paulo, Brazil.

inoculation experiments with other host species, and we shall only mention that in the work with this strain, as well as with the other necrotic strains, we made sure to include *Datura stramonium* among the test species. With none of the strains referred to did we succeed in obtaining infection in *Datura stramonium;* this, together with observations on the physical qualities of the causal agents *in vitro*, may be taken as a proof that all of them really are strains of potato virus Y.

Our second strain of potato virus Y, which induced vein necrosis as a systemic symptom in sap inoculated White Burley tobacco plants, was obtained from a Bolivian potato variety called Pacena. We had received tubers of that variety as well as of 18 other Bolivian potato varieties, by the kindness of Prof. Martin Cardenas of Cochabamba in July 1942. All these tubers came from the Experimental Farm Toralapa, situated at 7,500 feet above sea level. We planted the tubers of these varieties in Sao Paulo immediately after their arrival and submitted the plants sprouting from these tubers to a great number of diagnostic tests.

The tubers of the variety Paceña, also probably belonging to *Solanum andigenum*, are round and have a violet skin and deep-set eyes. The plant grown from one of the tubers was characterized by wiry sprouts and developed into a weak plant consisting of many delicate shoots bearing small chlorotic leaves. Sap of that plant contained the strain necrotic to tobacco, which we called Pacena after the potato variety from which it was derived. The necrotic symptoms induced by this strain in White Burley tobacco plants are of the general type we considered typical for our Serrana negra strain but are generally somewhat milder than these. In the case of the Pacena strain also, the necroses generally involve the smaller veins; sometimes, however, they may consist only of round white spots scattered over the leaf surface, especially in a later stage of the disease.

This strain, which we more simply than correctly call the Bolivian strain, was also derived from a potato the tubers of which we obtained with a large collection from Prof. Martin Cardenas of Cochabamba. The tubers of the new collection also had been harvested on the Experimental Farm Toralapa in Cochabamba. This new collection arrived in Sao Paulo 11 years after the first one or exactly on August 24, 1953. The virus strain which is of interest to us was harbored by a tuber of a variety of *Solanum andigenum* called Imilla blanca, which had been produced by a crinkle leaved plant. In our greenhouse, the tuber also gave rise to a diseased potato plant, characterized by chlorotic, aucuba-like spots on the lower leaves.

The sap from these leaves induced again systemic symptoms of vein necrosis in the young leaves of White Burley tobacco plants. The experiments on this strain, to which we shall refer later, are still in progress.

Before considering some details of our experiments, I want to complete the history of our acquisitions of necrotic strains of potato virus Y by mentioning that we received a sample of the German strain, the causal agent of the "Tabakrippenbräune" on August 19, 1955 two years after the receipt of the Bolivian strain. We owe the German strain to the kindness of Prof. Bode of Braunschweig. It was harbored by tobacco, and not by potato, but it induced in our White Burley indicator variety symptoms very similar to those induced by the strains mentioned before.

The list of necrotic strains of potato virus Y used in our experiments would be incomplete if we did not mention 2 strains picked up—contrary to the other strains—in Brazil and not derived originally from potatoes but from other solanaceous hosts. Neither of these strains generally induces vein necrosis in leaves of White Burley tobacco plants.

The first of these strains, called "virus das Solanaceas" (Solanaceous virus), isolated on June 5, 1952, from a solanaceous plant (possibly *Capsicum*) growing wild in the neighborhood of Sao Paulo, is responsible for a symptom pattern characterized by necrotic and chlorotic spots on young leaves of infected White Burley tobacco plants. This strain was described by Silberschmidt, Rostom, and Ulson (13), and later was exhaustively studied by Easton, Larson and Hougas (5) in Madison and by Bartels (2) in Braunschweig.

The second one of the necrotic strains, the symptom pattern of which does not normally include vein necrosis, was originally harbored by a tobacco plant and was tested for the first time in July, 1956. In successive subinoculations, it induced a reddish necrosis of the principal veins in leaves of tomato (in acropetal order of the leaves) but only vein-banding and mottling in tobacco plants. Sometimes a few necrotic spots appeared on systemically infected plants of White Burley. This strain has not yet been described in the literature.

Summarizing this historical part of our report, we may conclude that the 3 strains of potato virus Y, which induce a symptom pattern in tobacco plants similar to that of the "Tabakrippenbräune" were originally harbored by potatoes sent to us from Peru and Bolivia. Our collection also includes 2 necrotic strains isolated from solanaceous plants growing in Brazil, but these 2 latter strains cause symptoms rather distinct from those of "Tabakrippenbräune."

Most of the necrotic strains of potato virus Y described by other authors may be traced back, not to Brazil, but to other countries of South America. This is true at least for the vein necrosis strain, described by Bawden and Kassanis (3), and studied later in great detail by Munro (8). The origin of the strain, or better of the mixture of strains, described by Smith and Dennis (17) is unknown. The strain shown by Kovachevsky (7) to cause necrotic symptoms in tobacco cultures in Bulgaria is also of unknown origin and may have been a forerunner of the one responsible for the epidemic rise of "Tabakrippenbräune" in Central Europe.

Passing now to the second part of this report, we want to refer to the results of experiments which we performed with the necrotic strains of potato virus Y listed before. We shall select for this purpose only results concerning:

[1] The transmissability of the necrotic strains of potato virus Y by aphids, [2] the susceptibility of potato varieties to the necrotic strains, and [3] cross-protection reaction between non-necrotic and necrotic strains of potato virus Y.

The tests of insect transmission with our first strain (Serrana Negra) were performed in cooperation with my pupils, N. R. Nobrega and A. Orlando (9, 10, 11). We showed that both *Myzus persicae and Macrosiphum solanifolii*, are capable of transmitting the virus to healthy plants but that *Myzus persicae* is the more effective vector. White Burley tobacco plants inoculated by means of the insects showed symptoms characterized

by the same severe vein necrosis displayed by the source plant. We accent this fact, because in the tests referred to by Smith and Dennis (17) the insect transmitted only what the authors call the "chlorotic phase". In all our transmission experiments with necrotic strains, the plants that became infected following inoculation with insects presented the full necrotic symptom pattern. The results of some of our experiments with the virus of Serrana Negra show that one single insect is capable of transmitting the virus. In other experiments it was demonstrated that the incubation period of the virus in the insect was very short, that transmission to successive groups of healthy plants is intermittent, and that when we offered a new healthy tobacco plant to a rather large batch of viruliferous aphids every 15 minutes the virus was seldom retained by the aphids for more than one hour. Moreover we could show that aphids submitted to a fasting period before having access to the virus source are more efficient vectors than comparable insects not submitted to fasting. When we made use of a fasting period of 3 hours and employed large numbers of aphids (around 30), the percentage of successful transmission from tobacco to tobacco was very high, sometimes 100 per cent. The percentage of positive transmission from potato to tobacco under identical experimental conditions was lower, but in any case it reached 87 per cent.

We mention these results because they have been confirmed in essential details not only by our own later experiments with necrotic strains of potato virus Y, (a test on May 6, 1954) with the Bolivian strain gave 80 per cent positive results and a recent test with a German strain resulted in 100 per cent infection) but also by the observations of other authors on the causal agent of "Tabakrippenbräune." In transmission experiments from tobacco to tobacco with the causal agent of "Tabakrippenbräune," in which *Myzus persicae* was used as a vector, Klinkowski and Schmelzer (6) obtained positive results in 76 per cent of the cases, and Bode and Völk (4) reported necrotic symptoms in 93 per cent of the tobacco plants to which viruliferous aphids had been transferred.

We shall now refer to some of our attempts to transmit a necrotic strain of potato virus Y to potato clones and potato seedlings by means of insect vectors. Our first tests, performed in cooperation with A. Orlando and with the strain Serrana Negra, were rather successful.

The potato plants used consisted of healthy tuber-grown plants of the Dutch varieties Bintje and Eigenheimer and of seedlings of the Bolivian variety Saccampaya.

In the tests in which we used diseased tobacco as a source species and *Myzus persicae* as the insect vector, we succeeded in inducing the disease in more than 80 per cent of the inoculated plants of Eigenheimer, in about 60 per cent of the Saccampaya seedlings, and in only 30 per cent of the Bintje plants. When we used Eigenheimer plants as virus sources for the transmission, the results were still better. In this case we could transmit the virus, by means of the insect vector *M. persicae*, to 100 per cent of the originally healthy plants of Eigenheimer tested and to 50 per cent of the seedlings of Saccampaya. The symptoms displayed by the infected potato plants were not pronounced, so we had to verify the exactness of the results by inoculating White Burley tobacco plants with sap obtained from the suspected potatoes.

If our attempts to transmit our first necrotic strain of potato virus Y

to *Solanum tuberosum* were relatively successful, the same may not be said of the other strains. As a matter of fact, we had great difficulty in transmitting any one of these strains to potato, either by sap or by insects. In a comparative test performed on March 12, 1956, we were unable to transmit either our Bolivian strain or the German strain to seedlings of the variety Ackersegen. But fortunately we did not fail entirely. On March 20, 1956, we succeeded in transmitting the German strain, that means one strain related to the "Tabakrippenbräune," to a seedling of the Bona variety. The positive result was again confirmed by sap inoculation to White Burley tobacco.

These observations draw attention to the almost paradoxical fact that experimentally it is not easy to infect potatoes with a virus which, in some countries, spontaneously has become a real menace to the potato

With regard to the difficulty in transmitting necrotic strains of potato virus Y to potato plants and seedlings, our observations are confirmed by the results obtained by Easton, Larson and Hougas (5), who worked with one of our strains. They failed to transmit this strain to clones of the varieties Bliss Triumph, Katahdin, Irish Cobbler, and many others but succeeded in inoculating mechanically 1 of 6 plants of Pontiac. Also the inoculation experiments of Bartels (1, 2) show that a necrotic strain related to the causal agent of "Tabakrippenbräune" seldom caused pronounced symptoms in the inoculated potato plants. Some plants did not become infected whereas in others the symptoms remained masked or were rather mild. This point illustrates one of the great difficulties encountered in the detection of such necrotic strains within the potato. On the other hand, the necrotic strains of potato virus Y may differ in the degree of virulence to potato. Richardson (12) reports on experiments with a necrotic strain of potato virus Y which infected potato varieties as readily as did typical strains of the virus. He believes that only a prior infection of the potatoes with a common strain of the virus prevents heavy infections by the necrotic strain.

We shall refer only in a few words to cross-protection tests between nonnecrotic and necrotic strains of potato virus Y, as we have presented some of the results of these experiments at the International Congress for Crop Protection in Hamburg. Since our first observations on the strain called Serrana Negra, published in 1944 in cooperation with our pupil Nelson Nobrega (10), we found again and again that the mild and common strains of potato virus Y occurring in Brazil offer tobacco plants only a partial protection against the harmful effects of a superinoculation with one of the necrotic strains. That does not exclude the possibility of choosing the experimental conditions (*e.g.* the interval between the two inoculations) in such a way that plants harbouring a mild strain display much less necrosis than do their companions inoculated only with the necrotic strain. But even so, the protection is generally not complete but only partial. On this point, most of the other authors concerned with this problem came to the same conclusion. Thus in the experiments of Bawden and Kassanis (3), the mild strains of potato virus Y tested by these authors failed to protect tobacco plants against tobacco veinal necrosis virus. Also the cross-protection tests referred to by Klinkowski and Schmelzer (6), with various mild strains of potato virus Y led generally only to a partial protection of tobacco and also of the Petunia plants

against the causal agent of "Tabakrippenbräune".

In the experiments of Munro (8), who worked with a strain of vein necrosis virus similar to our Serrana Negra strain, a few mild strains of potato virus Y failed entirely to protect tobacco plants against the necrotic strain; others, as in our own tests, caused a delay in the development of symptoms and a decrease in their severity.

In the final part of this report on our activities related with necrotic strains of potato virus Y, I want to refer to the recent introduction into Brazil of necrotic strains of that virus by way of certified seed potatoes imported from Germany and other countries of Central Europe. We have already called attention to the fact that our strains of potato virus Y causing vein necrosis do not derive from Brazil but from other countries of South America. As a matter of fact, only since the rise of "Tabakrippenbräune" in Europe have such strains been introduced into Brazil.

In the Biological Institute in Sao Paulo, we are in a good position to verify the extent of these introductions. In the first place, we receive from the I.C.A., which acts in cooperation with the Brazilian Federal Department of Agriculture, samples of all lots of seed potatoes entering the country. We also receive samples of tubers suspected to bear virus disease from the potato growers or the inspectors of seed potato plantations. One sprout of each of these tubers is grown in our greenhouses, and records are taken of its development. If a young plant shows disease symptoms, sap inoculations are made to a series of indicator species.

Early in 1959 we tested samples of 18 lots of first grade seed potatoes of several varieties imported from Germany, Holland, Sweden and Denmark.

From each lot, 30 eyes were planted in pots and the sprouts grown in the greenhouse. Sap from at least three of these sprouts was rubbed on indicator species. None of the varieties imported from Holland, Sweden, or Denmark were found to contain a necrotic strain of potato virus Y. Three of the 9 lots of potatoes imported from Germany were shown to harbor necrotic strains of Y virus. In the varieties Heida and Fina the percentage of infection was probably rather moderate, since only the sap of one of 4 tested plants of each variety induced necrotic symptoms in White Burley tobacco (Fig. 1). The lot corresponding to the Augusta variety was infected to a very high extent, since 6 of 7 tested plants (85 per cent), contained the causal agent of "Tabakrippenbräune." Considering the fact that the Brazilian farmer at the present exchange rate pays fabulous amounts for one box of certified seed potatoes, this result demonstrates the need for the development of efficient methods for the diagnosis of that disease in the country of the origin of the seed.

A more recent test was performed with 5 samples of second grade potato seed (Nachbau) imported from Germany. No necrotic strains of potato virus Y were found in the tested plants of the varieties Marita, Oda, and Eva. Some of the tubers of the variety Jacobi, however, and a high percentage of those of the variety Benedikta—85 per cent of the tested plants—carried a necrotic strain of potato virus Y. During the course of the inoculation experiments, we kept the potato plants growing in the greenhouse, since we wanted to determine the relation between virus content and symptoms. Our observations confirmed what Bartels (1) had stated before, namely, that the symptoms on potato caused by the necrotic strains vary widely. In some varieties the symptoms were entirely

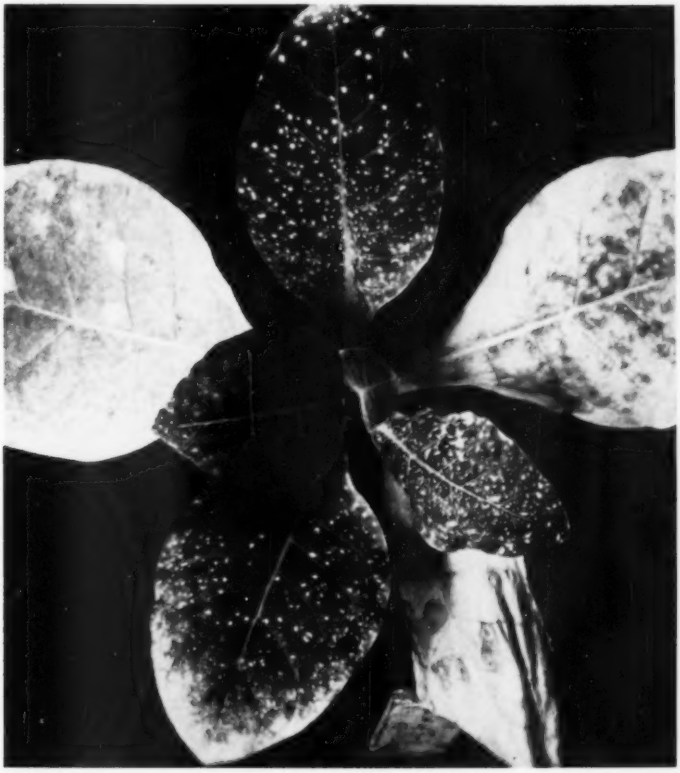

FIGURE 1.—White Burley tobacco inoculated with sap of the sprout of a potato tuber (variety Fina) belonging to a lot of certified seed imported from Germany (May 2, 1959).

masked; in other varieties they consisted of a very severe necrotic symptom pattern. We found that often the plants of the varieties Augusta and Fina, harboring a necrotic strain of potato virus Y, were characterized by small, slightly mottled or chlorotic leaves.

Augusta potato plants containing a necrotic strain of potato virus Y bear many weak shoots, and the leaves are small and somewhat chlorotic. Often the virus causes a stunting of the plants of the variety Jakobi. There are also cases in which the potato plants containing the necrotic strain display necrosis on the leaves and even along the shoot. Such symptoms are found in diseased plants of the variety Benedikta, many plants of which contained this virus and all infected plants died prematurely.

So far, we have mentioned only the results of our experiments with freshly imported seed potatoes. As we also receive samples of tubers (from potato plantations) of hills supposed to contain virus, we are in a position to affirm that certified seed potatoes containing the causal agent

of "Tabakrippenbräune" have been planted in Brazil. The first unshakable proof of the disturbing fact was found by us when we discovered that all of the tubers of a plant of the variety Augusta grown in Rio Grande do Sul from certified seed imported from Germany contained the causal agent of "Tabakrippenbräune." The tubers of that diseased plant, harvested in May 1958 and sent to us by Dr. Deslandes of the I.C.A., were the first home-grown tubers proved to contain the necrotic strain of potato virus Y. At about the same time we found a similar strain of potato virus Y in leaves of Heida plants grown in the State of Sao Paulo from certified seed imported from Germany. The peculiar symptoms exhibited by the leaves consisted of brown necrotic disks and rings (Fig. 2).

Herewith we are closing the circle of this report extending over many years. We started very early studying necrotic strains isolated from tubers grown in other countries, and we are now in the unhappy situation of being able to pick up samples of imported strains in our own backyard.

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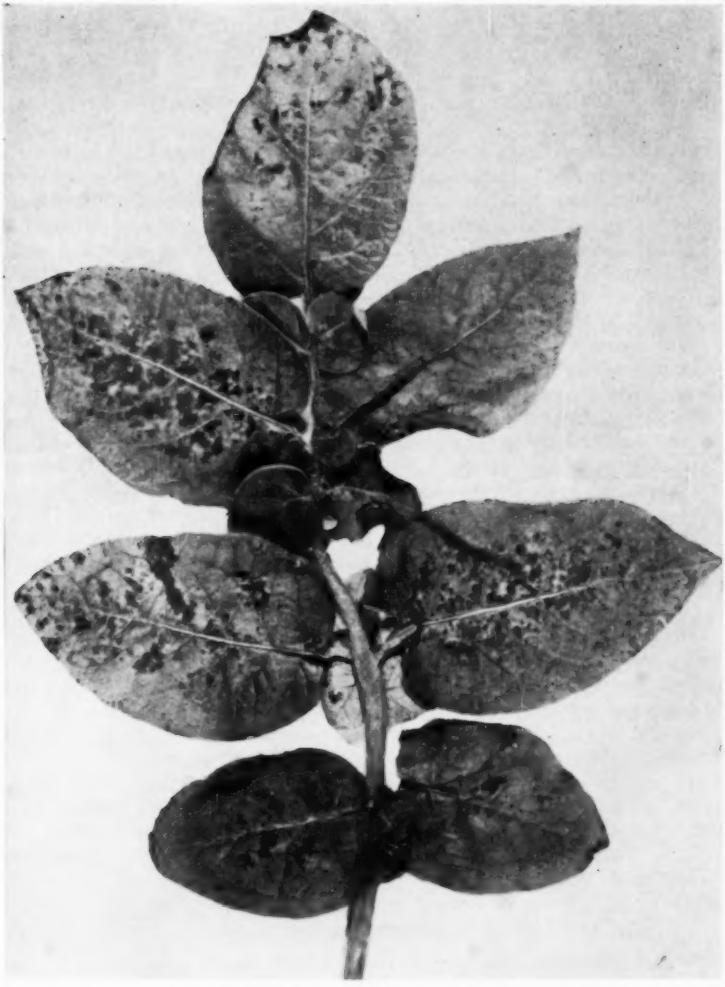

FIGURE 2.—Irregular necrotic spots covering leaf of a plant of the potato variety Heida grown in Brazil from certified seed imported from Germany. The plant was shown to contain a necrotic strain of potato virus Y. (Sept. 18, 1958).

EFFECTS OF GLYCEROLMONOSTEARATE ON RECONSTITUTED POTATO GRANULES[1]

W. O. HARRINGTON[2], R. L. OLSON, AND MARVEL-DARE NUTTING[3]

One of the problems facing the producer of dehydrated mashed potatoes is the reconstituted characteristics of finished product. Cooley et al. (1) and Neel et al. described many of the problems in product handling during production which affect quality. Harrington et al. (11) and Olson et al. (15, 16, 17, 18) have studied other production variables affecting quality. This information has made possible the production of potato granules which can be reconstituted over a wide range of temperatures into a product which closely resembles freshly mashed potatoes.

The reconstitution characteristics of dehydrated mashed potatoes can be altered by the addition of starch-complexing agents such as glycerolmonostearate, glycerolmonolaurate, glycerolmonopalmitate, stearic acid, etc. At the second Potato Granule Conference June 24-25, 1954, Cooley (1) described textural changes in potato granules containing glycerolmonolaurate. Samples produced at the University of North Dakota by Cooley, with and without 0.5 per cent by weight of glycerolmonolaurate, were appraised by a panel at Western Utilization Research and Development Division according to the methed of Wood et al. (19). All samples with the additive showed increased mealiness and less rubberiness than those with no additive.

Cording et al. (3, 6) have shown glycerolmonopalmitate to be effective in control of reconstituted potato flakes texture. He observed that the addition to the mash of 0.25 per cent glycerolmonopalmitate on a dry solids basis produced a marked increase in mealiness before drying. Other work by Cording et al. (2, 4, 5, 7, 8), Eskew (9), and Eskew et al. (10), concerning the use of glycerolmonopalmitate and the control of reconstitution variables affecting potato flakes, has enabled producers to obtain the desired textural quality in this product.

Studies have been conducted at the Western Regional Research Laboratory on effects of glycerolmonostearate[4] as a starch-complexing agent affecting texture of potato granules, either freshly prepared or under simulated steam-table conditions.

MATERIALS AND METHODS

The standard procedure for production of potato granules by the add-back method is discussed by Harrington et al. (11).

Glycerolmonostearate (GMS) was incorporated with potato granules by 3 different methods: (a) GMS powder was prepared by grinding with dry ice and allowing the excess carbon dioxide to evaporate. This powder was then mixed with dry potato granules before reconstitution into the

[1]Accepted for publication November 13, 1959.

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mashed product. (b) A mixture of potato granules and 20 per cent GMS by weight, was held a few minutes in an oven at a temperature above the melting point of GMS. This mix was then added to granules before reconstitution to give the desired per cent of GMS by weight. (c) GMS was added to the potatoes during the hot mash-mixing step in preparation of granules. At this stage there was sufficient heat to melt and mix the GMS thoroughly. In some instances GMS added at other stages tended to separate out and stick to the drying equipment.

Samples were prepared by blending various amounts of the above mixtures with untreated granules, just before reconstitution or during production, in order to determine the quantitative relationship between GMS and texture quality of the finished product.

In order to test the effect of GMS on reconstituted potato granules under steam-table conditions, samples were placed in closed jars to prevent moisture loss, and held 3 hours at 170° F. and 4 hours at 150° F.

A further series of tests was done to determine the effect of 1.25 per cent GMS, 5.0 per cent raw potato starch, or a combination of the two.

The method of appraisal of potato granules was that of Wood et al. (19) using a reconstitution temperature of 160° F. and comparing test samples against two reference samples which differed in degree of rubberiness or mealiness. This method was altered slightly to include reconstitution temperatures of 180° and 200° F. with and without additive.

The Blue Value Index of Mullins et al. (12), in which an extract of potato granules is treated with iodine solution, has proved helpful in process development. An increase in starch-iodine blue color, measured colorimetrically, is an indication of more free starch accompanied by an increased pastiness of the product. The Blue Value Index correlates well with texture when there are no large differences in raw materials or production procedure. However, the GMS complex with the straight-chain amylose of the free starch reduces the amylose-iodine blue color to a pale blue, usually cloudy, solution. Therefore this method was less useful in evaluating the quality of potato granules when GMS had been added.

The physical consistency test developed by Mullins et al. (13) was found very effective for evaluating texture differences. Potato granules were reconstituted under standardized conditions. A weighed ball of mashed potatoes was dropped from a fixed height to a flat surface. The diameter and appearance of the dropped cake were indicative of the texture of the product; the larger the diameter the more mealy the texture.

Discussion and Results

Addition of GMS to potato granules either before reconstitution or during production, gave a more mealy final product. Table 1 shows the texture ranks and cake diameters of 3 commercially prepared and one experimental lot of potato granules with 0.25 per cent GMS added as a powder just before reconstitution. All were reconstituted at 180° F. and showed lower numerical ranks for texture of the treated samples, indicat-

[4]Individual manufacturers should consult the Food and Drug Administration, Washington 25, D. C. and the Food and Drug officials of the individual states involved to determine whether the use of any proposed additive is permissible, and if so, what limitations are placed on its use.

TABLE 1.—*Effect of 0.25 per cent GMS on consistency of potato granules.*

Samples	Texture Ranks		Cake Diameter — Mm.	
	Untreated	GMS	Untreated	GMS
A	1.95	1.05	60	62
B	1.93	1.07	63	70
C	1.93	1.07	64	79
D	1.80	1.20	67	72

Rank 1.0 = least rubbery, most mealy; 2.0 = most rubbery or sticky.
A, B, and D are commercial lots; C is the experimental lot prepared at this laboratory.

ing a less rubbery, more mealy product than the control with no GMS. The diameters of the treated samples were greater than those of the untreated, indicating an increase in mealiness.

When 0.25 per cent GMS was added to the system during preparation of potato granules by the add-back method (11) several changes were observed. The GMS caused an increase in yield of product from 24 per cent of fresh potato weight to 26 per cent; a major decrease in Blue Value Index from 72 to 20; a slight decrease in bulk density from 0.87 to 0.85 gm./ml.; and an increase in cake diameter from 71 to 89 mm. by the Mullins consistency test. Similar observations in another test using 0.55 per cent GMS showed an increase in yield of fines or packout passing a 70-mesh screen from 84 to 90 per cent of dry product, and in cake diameter from 63 to 81 mm.; and a decrease in Blue Value Index from 83 to 30, and in bulk density from 0.90 to 0.88 gm./ml. The color values did not always correlate well with results of subjective appraisal due to reduction of color by the GMS complexes as previously mentioned.

GMS had less effect on consistency of mashed potatoes reconstituted at 160 than at 180 or 200° F. At the higher temperature as little as 0.125 per cent by weight of GMS improved consistency, especially if potato granule samples of good quality were used. However, in the case of poor-quality potato granules, the breakdown to free starch at reconstitution temperature of 200° F. was sometimes great enough to offset the effect of GMS.

The effect of concentration of GMS on consistency of samples of reconstituted granules is shown in Table 2. The diameter of the cakes increased with increased percentage of GMS up to 2.0 per cent, but there was no further increase with 3.0 and 5.0 per cent GMS.

Fig. 1 shows one of the 3 cakes made during the 5 consistency tests with added amounts of GMS up to 2.0 per cent. The shattering and fissuring of the dropped cake caused considerable breaking off of the edges and reduced accuracy of measurement but did indicate the shortness and reduced stickiness of the dropped cake.

In the steam table experiments the untreated samples held at 150° F. for 4 hours and 170° F. for 3 hours exhibited similar deterioration trends, while those containing 0.25 per cent GMS always remained more mealy. Furthermore, the better the initial quality of mashed potatoes the better

TABLE 2.—*Effect of different percentages of GMS on consistency of potato granules.*

GMS Per cent	Cake Diameter Mm.	Appearance	Texture
0	61	Smooth	Fair
0.25	62	Light fissures	Mealy
0.50	66*	Deep fissures	Very mealy
0.75	65	Deep fissures	Very mealy
1.0	69	Deep fissures	Very mealy
1.5	68	Deep fissures	Very mealy
2.0	72	Deep fissures	Very mealy
3.0	67	Deep fissures	Very mealy
5.0	68	Deep fissures	Very mealy

*Edges badly separated, measuring difficult.

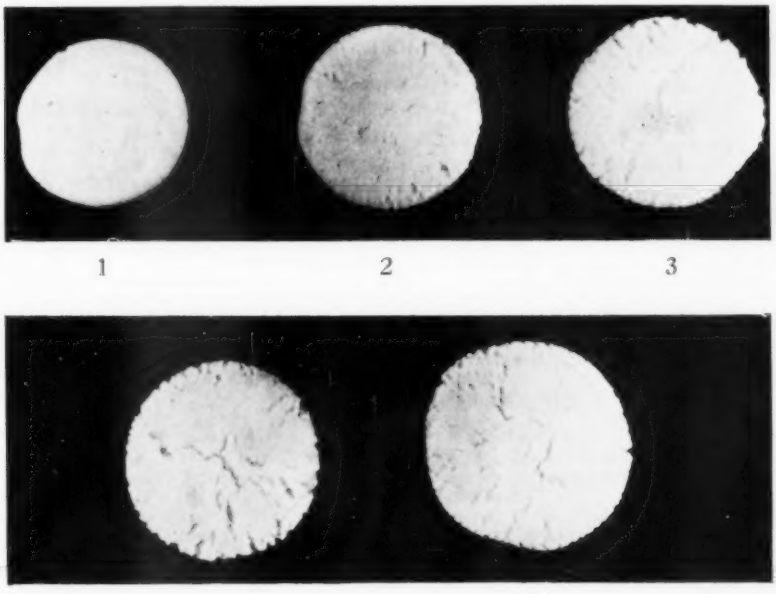

FIGURE 1.—Fracturing and fissuring due to increasing percentages of GMS. 1 = untreated sample, no GMS; 2 = 0.75 per cent GMS; 3 = 1.0 per cent GMS; 4 = 1.5 per cent GMS; 5 = 2.0 per cent GMS.

they were after steam-table holding, whether additives had been used or not.

The study with 1.25 per cent GMS and 5.0 per cent starch showed that GMS increased cake diameter, starch decreased it, and the combination gave a diameter equal to the untreated sample.

Summary

The texture of reconstituted potato granules can be altered to give a more mealy product by the use of glycerolmonostearate. GMS can be added either during production by blending or as a powder or mix at time of reconstitution. The quality of the original potato granules is the greatest factor in producing a good reconstituted mashed potato product, with or without addition of GMS. During this study there were no adverse textural or flavor effects attributed to GMS.

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A SHORTER METHOD FOR EVALUATING THE ABILITY OF SELECTIONS TO YIELD CONSISTENTLY OVER LOCATIONS[1]

R. L. PLAISTED[2]

Once the potato breeder has obtained his true seed, he must satisfy two requirements for success. First, he must maintain disease free planting stock and second he must carry out his selection in an efficient and effective manner. In the more difficult final stages of selection the breeder tests his selections in regional yield trials. These not only give information about yield in specific locations and seasons but can also be used as a measure of the consistency of their cropping ability. A method was presented in 1959 (2) for making numerical estimates of this consistency of cropping ability using the regional yield trial data already being assembled. An alternate method is proposed which produces the same results with less computational effort.

METHOD

For illustrative purposes let us assume that the regional yield trial consists of 2 locations each with the same 4 varieties in 2 replications planted in a randomized complete block design. Most breeders substitute new entries into their regional trials each year. The analysis of variance model for this type of trial is

$$Y_{ijkl} = U + (VY + V)_i + L_j + (VLY + VL)_{ij} + R_{jk} + E_{ijkl}$$

where Y_{ijkl} is the yield on the $_{ijkl}$th plot, U is the mean effect common to all observations, $(VY + V)_i$ is the confounded effect of the $_i$th variety and its interaction with the particular year in which the trial is conducted, L_j is the effect of the $_j$th location, $(VLY + VL)_{ij}$ is the confounded effect of the interaction of the $_i$th variety and the $_j$th location in the single year the trial is conducted, R_{jk} is the effect of the $_k$th replicate at the $_j$th location, and E_{ijkl} is experimental error variation associated with the $_{ijkl}$th plot.

In practice, the source $(VY + V)_i$ probably should be considered fixed in that the population of varieties of interest are the ones contained in the trial. The other sources would probably be considered random since they represent a sample of a larger range that is of interest, thus they would be random, independent variates distributed around zero. To facilitate understanding the method of analysis we shall impose the restriction on all sources that the sum of the effects in a given source equal zero. This is the type of restriction given to fixed effects.

[1]Accepted for publication October 26, 1959.
[2]Plant Breeding Department, Cornell University, Ithaca, N. Y., Paper No. 382.

Let us assign the following effects to the model:

Mean effect	Location effects	Variety × Location interaction effects	
$U = 8$	$L_1 = +1$	$(VLY + VL)_{A1} = +1$	$(VLY + VL)_{A2} = -1$
	$L_2 = -1$	$(VLY + VL)_{B1} = +2$	$(VLY + VL)_{B2} = -2$
		$(VLY + VL)_{C1} = 0$	$(VLY + VL)_{C2} = 0$
		$(VLY + VL)_{D1} = -3$	$(VLY + VL)_{D2} = +3$

Replicate effects	Variety effects
$R_{11} = +1$	$(VY + V)_A = -1$
$R_{12} = -1$	$(VY + V)_B = -2$
$R_{21} = +1$	$(VY + V)_C = 0$
$R_{22} = -1$	$(VY + V)_D = +3$

Experimental error effects

$e_{A11} = -3$	$e_{A12} = +3$	$e_{A21} = +2$	$e_{A22} = -2$
$e_{B11} = +2$	$e_{B12} = -2$	$e_{B21} = +1$	$e_{B22} = -1$
$e_{C11} = +1$	$e_{C12} = -1$	$e_{C21} = -3$	$e_{C22} = +3$
$e_{D11} = 0$	$e_{D12} = 0$	$e_{D21} = 0$	$e_{D22} = 0$

When these values are substituted into the model, the results given in table 1 are obtained.

TABLE 1.—*Data.*

	Location 1			Location 2			
Var.	Rep. 1	Rep. 2	Sum.	Rep. 1	Rep. 2	Sum.	Var. Total
A	7	11	18	8	2	10	28
B	12	6	18	5	1	6	24
C	11	7	18	5	9	14	32
D	10	8	18	14	12	26	44
Totals	40	32	72	32	24	56	128

The first step in the analysis is to compute a separate analysis of variance (AOV) for each location. In this case the results are given in table 2.

The second step is to combine these separate AOV over all locations. Table 3 shows how this may be accomplished. As a precaution, it should be noted that the interpretation of the results of the combined analysis is more meaningful if the error variances of the separate AOV are random variables of the same population.

To show that the sum of squares obtained in table 3 are clearly a function of the effects from which the data were derived let us derive the variety × location sum of squares. If all other effects are ignored, the variety × location effects were assigned as follows:

TABLE 2.—*Separate AOV for each location.*

	Location 1		Location 2	
	df	SS	df	SS
Total	7	36	7	148
Reps	1	8	1	8
Varieties	3	0	3	112
Error	3	28	3	28
Computational data				
Correction factor		648		392
Uncorrected total SS		684		540

TABLE 3.—*Separate AOV combined over locations.*

	df	SS	
Total	15	200	684 + 540 — 1024
Location	1	16	648 + 392 — 1024
Reps in location	2	16	8 + 8
Var. in location	6	112	0 + 112
Var	3	56	$(28^2 + 24^2 + 32^2 + 44^2)/_4 - 1024$
Var × loc	3	56	112 — 56
Error	6	56	28 + 28 = 200 — 16 — 16 — 112

Correction factor = $128^2/_{16} = 1024$

d.f.:

Total	= total number of plots — 1
Location	= number of locations — 1
Reps in loc	= sum of d.f. for reps in all the separate AOV
Var in loc	= sum of d.f. for varieties in all the separate AOV
Var	= number of varieties — 1
Var × loc	= d.f. for var × d.f. for location
Error	= sum of d.f. for error in all the separate AOV.

SS:

Total SS	= sum of all uncorrected total SS from individual analyses — overall correction factor.
Location	= sum of all correction factors from separate AOV — new overall correction factor
Reps in loc	= sum of all SS for reps in separate AOV
Var in loc	= sum of all SS for var in separate AOV
Var	= sum of squares of variety totals divided by total number of observations in each total — correction factor
Var × loc	= variation in location SS — var SS
Error	= by subtraction or by adding error SS from individual AOV.

If the F for the variety × location Mean Square divided by the error M.S. is significant (in this example, it is not), then proceed with the next step.

Construct a table similar to table 4. This table simplifies subsequent computations.

	Location 1		Location 2	
Var	*Rep 1*	*Rep 2*	*Rep 1*	*Rep 2*
A	+1	+1	−1	−1
B	+2	+2	−2	−2
C	0	0	0	0
D	−3	−3	+3	+3
	0	0	0	0

Note that $4\ [(\pm1)^2 + (\pm2)^2 + (\pm0)^2 + (\pm3)^2] = 56$

TABLE 4.—*Sums of squares accumulated by variety.*

Var	Contribution to Uncorrected Total SS		Contribution to Uncorrected Var × Loc SS	
A	$7^2 + 11^2 + 8^2 + 2^2 =$	238	$(18^2 + 10^2)/_2 =$	212
B	$12^2 + 6^2 + 5^2 + 1^2 =$	206	$(18^2 + 16^2)/_2 =$	180
C	$11^2 + 7^2 + 5^2 + 9^2 =$	276	$(18^2 + 14^2)/_2 =$	260
D	$10^2 + 8^2 + 14^2 + 12^2 =$	504	$(18^2 + 26^2)/_2 =$	500
		1224		1152

Next compute a combined AOV, each time omitting a different variety. In our example, let us omit variety A. A new set of totals are needed. They are as follows:

	Location 1			Location 2			Grand
	Rep 1	Rep 2	Total	Rep 1	Rep 2	Total	Total
Varieties (B + C + D)	33	21	54	24	22	46	100

Each of these combined AOV omitting in turn a successive variety may be computed as outlined for the combination of all varieties. However, the method outlined in table 5 is somewhat shorter.

TABLE 5.—*Combined AOV omitting variety A.*

	df	SS	Mean Square	Expected Mean Square
Total	11	152.7		
Location	1	5.4		
Reps in loc	2	24.6		
Var in loc	4			
Var	2	50.7		
Var × loc	2	50.6	25.3	$\sigma^2 + k(\sigma^2_{VLY} + \sigma^2_{VL})$
Error	4	21.4	5.35	σ^2

k = number of reps per loc.

c.f. $= 100^2/12 = 833.3$

Total SS = total uncorrected SS from combined AOV of all varieties — contribution of the omitted var. — this new c.f.
$= 1224 - 238 - 833.3 = 152.7$

Loc SS = sum of each location total squared divided by number of observations in each total — c.f.
$54^2 + 46^2/6 - 833.3 = 5.4$

Reps in loc SS = sum of each rep total squared divided by the number of varieties — correction factor — Loc SS

$= (33^2 + 21^2 + 24^2 + 22^2)/3 - 833.3 - 5.4 = 24.6$

Var SS = sum of each variety total squared divided by number of observations in each total — c.f.

$= (24^2 + 32^2 + 44^2)/4 - 833.3 = 50.7$

(V × L)SS = (total uncorrected (V × L)SS — contribution of the omitted variety) — Var SS — Loc SS — c.f.

Error SS = by subtraction

$152.7 - 5.4 - 24.6 - 50.7 - 50.6$

Again let us use the variety × location sum of squares to illustrate how the assigned effects have produced the SS given in the analysis. If all other effects are ignored and variety A is omitted, the following variety × location effects were assigned to the data analysed in table 5:

	Location 1		Location 2	
Var	*Rep 1*	*Rep 2*	*Rep 1*	*Rep 2*
B	+2	+2	−2	−2
C	0	0	0	0
D	−3	−3	+3	+3
	−1	−1	+1	+1

Note that the sum of the effects within replications within locations is not zero. Therefore the effect of locations in this analysis has been changed by the average of this amount, $\pm 1/3$. Let us remove this effect from the variety × location effects:

	Location 1		Location 2	
Var	*Rep 1*	*Rep 2*	*Rep 1*	*Rep 2*
B	$+2 + 1/3 = 2\frac{1}{3}$	$2\frac{1}{3}$	$-2 - 1/3 = -2\frac{1}{3}$	$-2\frac{1}{3}$
C	$0 + 1/3 = \frac{1}{3}$	$\frac{1}{3}$	$0 - 1/3 = -\frac{1}{3}$	$-\frac{1}{3}$
D	$-3 + 1/3 = -2\frac{2}{3}$	$-2\frac{2}{3}$	$3 - 1/3 = 2\frac{2}{3}$	$2\frac{2}{3}$
	0	0	0	0

Obtain the sum of squares of these effects.

$4[(\pm 2\frac{1}{3})^2 + (\pm \frac{1}{3})^2 + (\pm 2\frac{2}{3})^2] = 50.7$

The difference between this and the 50.6 of Table 5 is due to rounding.

Table 5 also gives the expected mean squares for the variety × location and error sources of variation. These are derived from the model and will be characteristic for analyses of regional yield trial data repeated over locations, but not seasons. If the number of replications

at each location is not the same the divisors in computing the sums of squares will be effected and the coefficient k of the interaction component will be an average value which can be calculated according to the formula:

$$\frac{1}{v-1}\left(\Sigma r_i - \frac{\Sigma r_i^2}{\Sigma r_i}\right)$$

The use of this formula is given by Federer (1) on page 105.

The next step is to compute the estimate of the variety $\times$ location component of variance ($\sigma^2_{VLY} + \sigma_{VL}{}^2$). This is done by subtracting the error mean square from the variety $\times$ location mean square and dividing the coefficient k. For example:

$$\widehat{(\sigma^2_{VLY} + \sigma_{VL}{}^2)}_A = (25.3 - 5.35)/_2 = 10.0$$

Similarly the estimates when the other varieties are omitted can be obtained. These are given in table 6.

TABLE 6.—*Estimates of the remainder* ($\sigma^2_{VLY} + \sigma_{VL}{}^2$) *when successive varieties are omitted from the analysis.*

Variety Omitted	Contribution to the V $\times$ L interaction	$\widehat{(\sigma^2_{VLY} + \sigma^2_{VL})}$
A	$\pm$ 1	10.0
B	$\pm$ 2	3.3
C	0	10.3
D	$\pm$ 3	— 5.0

DISCUSSION

The analysis of this small example shows how the final results recover the information on interaction put into the model. The larger the contribution of a variety to the variety $\times$ location interaction, the smaller will be the estimate of the remainder interaction component of variance. Therefore in the analysis of real data with estimates of the remainder interaction component of variance ranked from high to low, the dependability of the variety will also be ranked from high to low.

This method gives results identical with those obtained with the method outlined in the first paper. Whereas the latter method of approach is not as logically straightforward, it involves less computational time and it is possible to apply a test of significance to the estimates obtained.

When this method was applied to the 4 years' data described in 1959, the results were identical with those described for those analyses. Of the three varieties repeated in all the years, Green Mountain was the most variable of all the varieties except in one year, Cobbler was very low in its variability except in one year, and Katahdin was also low in its variability. These results are in agreement with past experience in this State with these varieties. They also point out the need for estimates based on more than one year's data due to the magnitude of the interaction of varieties $\times$ locations $\times$ years. It is not uncommon that this

second order interaction is larger than either of the first order interactions, varieties × locations and varieties × years. However, this precaution imposes no real burden on the potato breeder since he would certainly include a selection in more than one or two years' regional yield trials before considering it for release.

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1. Federer, W. T. 1955. Experimental design. The Macmillan Co., New York.
2. Plaisted, R. L. and L. C. Peterson. 1959. A technique for evaluating the ability of selections to yield consistently in different locations and seasons. Am. Potato J. 36: 381-385.

SPREAD OF RUGOSE MOSAIC AND LEAF ROLL IN DIFFERENT VARIETIES OF POTATOES IN THE PLAINS OF WEST BENGAL[1]

H. C. CHOUDHURI[2]

Since the survey of aphid population in West Bengal by Choudhuri (3), a series of experiments on the spread of rugose mosaic and of leaf roll have been made to obtain information on the relative amounts of transmission of the two viruses year after year.

The potato-growing tracts of West Bengal lie mainly in the plains, where the infestation of aphids during the growing season is heavy. The seed-growing areas at an altitude of 6,000 feet and above, where the aphids are negligible or absent, are very limited. Consequently, most seed potatoes are produced in plains which lie between 34 feet to 98 feet above mean sea-level. Information as to the relative accumulation of these two viruses under field conditions in vareities of potatoes in different seasons is very meagre. This study is primarily an attempt to get information on the natural spread and accumulation of these two viruses in different varieties of potatoes.

MATERIALS AND METHODS

All experiments were made with forty different varieties repeated for four seasons *viz.*, 1954-1955 to 1957-1958. Disease-free seed produced at an altitude of 7,200 feet at Bhanjang Potato Experimental Station, Darjeeling, West Bengal (India), were planted in the plains at the State Agricultural College Experimental Farm, Calcutta.

The varieties were grown in replicated rows for four seasons, each year the crop was stored at 36° F. and a relative humidity of 85 to 95 per cent; all seeds used after the first year were taken from the previous year's crop. There were four rows of each variety with ten plants in each row. One tuber from each plant was removed at the end of February each year when the crop matured, for planting in the next season.

The State Agricultural College Experimental Farm is located in a non-industrial area but is bounded on all sides by an industrial area. There are a few small villages in the South, and there are no other fields within one mile.

Disease readings were made once each season at the end of February and based entirely on symptoms.

RESULTS

The incidence of both leaf roll and rugose mosaic was found to increase during the season from year to year except during the first two cropping seasons *i.e.* 1954-1955 and 1955-1956, when no visible symptoms of these diseases were observed in most of the varieties following the planting of disease-free seeds. Symptoms of these two viruses appeared during the third cropping season, and increased in the fourth.

[1]Accepted for publication November 13, 1959.
[2]Department of Agriculture, West Bengal Writers' Buildings, Calcutta, India.

Although forty different varieties were involved in these experiments, the results are shown for 16 varieties only. These varieties are commonly grown and showed resistance to leaf roll and rugose mosaic. The other varieties tested were Rungbull-3, Australian Red, Webers, Inverness Favourite, Deodara, Katahdin, Australian White, Canus, Arran Peak, Krassava, Eigenheimer, Darjeeling Blue Purple, Alpha, Dianella, Alma, Sherkov, Bintze, Nepal White Round, Gold Pearle, Robusta, King Edward, President and Darjeeling Red Round.

In Table 1 is shown the incidence of leaf roll and rugose mosaic in sixteen commonly grown varieties. It is apparent from the table that some varieties showed higher incidence of disease than others even though grown under identical conditions.

The varieties, Voran, Rungbull-12, Royal Kidney, Magnum Bonum, Sebago, Irish Cobbler, Bonderslev and Northern Star showed some resistance to the diseases even during the third cropping season. Tests of twenty-four other varieties showed symptoms of these diseases from the second cropping season.

Discussion

The rate of spread of rugose mosaic and leaf roll varies, depending on variety and locality. Broadbent and Gregory (1) in England showed that nearly one-half of the total amount of virus transmission had taken place soon after tuber set; early lifting of potatoes intended for seed had some beneficial effect at a given locality. The amount of early transmission of Y and leaf roll viruses tended to be similar to that in previous years, although the final amount of transmission of these viruses was sometimes widely different. In the present study, the incidencee of rugose mosaic and leaf roll were wideley different in many varieties. Also the different varieties varied widely in susceptibility to rugose mosaic and leaf roll. Chattopadhyay and Das (2) reported considerale variation in susceptibility to rugose mosaic and leaf roll in the varieties, Royal Kidney, Up-to-date and Darjeeling Red Round. They have also indicated that the incidence of leaf roll was not so variable as that of rugose mosaic in different varieties and localities.

Table 1 shows the variation of susceptibility in varieties to rugose mosaic and leaf roll. This variation was probably caused by the different genotypes in the varieties The appearance of disease may be influenced by the initial infestation of vectors but there is no close correlation between the spread of virus diseases and the maximum number of aphids per plant as has been shown by Broadbent and Gregory (1) and Choudhuri (3). The different types of resistance and susceptibility occurring in varieties are due mainly to their genetic differentiation as has been found in wild species of potatoes by Ross (4).

Summary

During the first two years there were no visible symptoms of rugose mosaic and leaf roll viruses. There were progressive increases of these viruses from the third cropping season of the experiment. Wide variation of susceptibility in varieties to leaf roll and rugose mosaic were noted. Some varieties showed some resistance to the viruses.

TABLE 1.—*Incidence of leaf roll and rugose mosaic, in successive years, in potato varieties planted in replicated plots with disease-free seed in 1954 and in succeeding years with seeds from the previous years' crop.*

Varieties	Percentage of plants diseased*				Total incidence
	Leaf roll		Rugose		
	1956-1957	1957-1958	1956-1957	1957-1958	
Rungbull—9	1.0	2.3	4.1	5.2	12.6
Ackersegen	0	0.9	2.1	4.3	7.3
Great Scot	0.3	1.1	2.3	5.5	9.2
Voran	0	0.3	0	2.3	2.6
Rungbull—12	0	0.4	0	2.1	2.5
Royal Kidney	0	0.5	0	2.0	2.5
Magnum Bonum	0	0.3	0	2.1	2.4
Taborky	0.3	1.0	2.5	6.5	10.3
Up-to-date	0.4	1.2	2.3	11.8	15.7
Arran Crest	0.6	1.1	2.1	6.4	10.2
Arran Consul	0.9	1.5	3.1	7.2	12.7
Sebago	0	0.4	0	2.1	2.5
Irish Cobbler	0	0.6	0	1.9	2.5
Bondersley	0	1.0	0	2.7	3.7
Northern Star	0	0.4	0	2.1	2.5
Graigs Defiance	0.8	1.1	4.2	6.4	12.5

*Symptoms of neither disease appeared in 1954-1955 or in 1955-1956.

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POTATO PLANTER ATTACHMENT FOR DISTRIBUTING WEIGHED QUANTITIES OF FERTILIZERS FOR PLOTS[1]

ARTHUR HAWKINS[2]

An attachment for a potato planter which will accurately distribute weighed quantities of fertilizer or chemicals has been developed. Several improvements have also been made on the original attachment.

Dr. S. M. Raleigh, Professor of Agronomy at Pennsylvania State University, while at the University of Maine, built the first endless belt type fertilizer distributor for experimental work, for a single row planter. He constructed it in 1939 for use by the author.

The most recent improvement is a quickly adjustable device for leveling fertilizer to uniform depth on the belt. Used properly it gives better insurance that the fertilizer is distributed evenly.

The fertilizer distributor attachment discharges fertilizer or chemicals from a horizontal belt. On the more recently designed attachments, the belt travels about four feet. A weighed quantity of fertilizer or chemicals is placed in a channel on the belt from the delivery gate to a point established in accordance with the length of the plot. A riser or tension block at this point keeps the fertilizer in place (Fig. 1 and 2). A leveling device levels the fertilizer to a uniform depth in order that the material may be discharged at a uniform rate.

Advantages in Use of Attachment

1. *Small plots and field plot designs:* Weighed quantities of materials can be distributed on plots a few feet to 271 feet in length with these attachments equipped with interchangeable gears.

A four or five foot alley between the end of one plot and the beginning of the next is ample. The use of this attachment permits precision placement of fertilizer in short plots in Latin Square or other field plot designs.

2. *Placement of fertilizer:* Fertilizer for short plots can be applied in side-bands at the time of planting; and the response information is applicable to commercial production. With hand spread applications the phosphorus comes in contact with more soil so that more of it is subjected to chemical fixation than if it were concentrated in side-bands. Fixation of phosphorus is of major importance in the East where potato soils are maintained strongly acid.

There is more chance for fertilizer seed-piece burn or seedling injury when the fertilizer is spread by hand in the row than when the fertilizer is placed by machine.

3. *Accuracy in uniformity of application of materials:* The fertilizer can be distributed more uniformly by machine than by hand. The machine permits greater precision of placement in relation to the seed.

4. *Other uses*: The attachment has been used to apply top or side dressings when the opening discs of the planter are removed. The fertilizer attachment can also be used for fertilizer tests on other row crops.

[1]Accepted for publication April 4, 1960.

[2]Agronomist, Storrs Agricultural Experiment Station, University of Connecticut, Storrs, Conn.

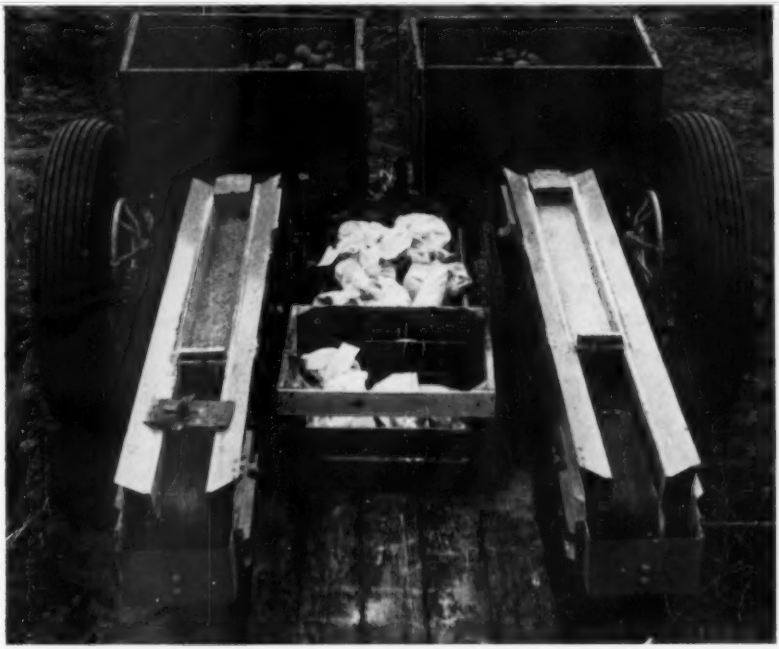

FIG. 1.—Top—Fertilizer distributor attachments on potato planter. Fertilizer is spread on belt from gate at delivery end to tension block at calibrated point for length of plot.

FIG. 2.—Side view showing jack shaft and interchangeable sprockets for varying speed of belt depending on length of plot.

Changes in Attachment

Following the design of the original attachment, the A. B. Farquhar Company under the direction of their Chief Engineer, the late W. W. Tranter, built units for a two-row planter in Maine in 1945 and for other experiment stations.

Upon request in 1946, W. W. Tranter prepared a drawing[3] to include the following suggested improvements which have been incorporated in attachments built since then: (1) belt travel was shortened to four feet to reduce the over-all length of the attachment; (2) provision was made for a sliding leveling device on the shoulders of the sides of the trough; (3) the width of the trough on the belt was reduced to four inches and (4) use of interchangeable sprockets to vary rate of belt travel.

Leveling Device[4]

The most recent improvement for the attachment is a quickly adjustable device for leveling fertilizer to a uniform depth on the belt. (Fig. 1 and 3). It consists of a metal scraper slightly narrower than the trough in which the fertilizer is placed and a metal strap or cross arm attached to the scraper by means of a bolt through a slot in the scraper. A spring provides the tension which makes the cross arm easy to adjust up or down on the scraper. The cross arm slides on the shoulders of the sides of the trough; it is adjusted in relation to the scraper to give uniform depth to the fertilizer. The scraper must be held *vertically* as it is drawn back and forth over the fertilizer.

Other Changes Suggested

(1) An adjustable stop suspended between the sides of the trough is more convenient than a solid flight or riser on the belt. (Fig. 1) With a riser the belt has to be turned until the riser registers with a calibrated point before fertilizer is placed on the belt.

(2) Without the riser the fertilizer will move slightly toward the front of the machine. This movement can be lessened by placing a small amount of soil in front of the layer of fertilizer as the belt moves away from the stop.

(3) Gates at the delivery end of two attachments can be raised or lowered at the same time by welding a long rod to them, and extending it enough at each end to create handles. A spring holds the gates open or shut by an offset arrangement.

Techniques in Use of Attachment

(1) Enough fertilizer is weighed out for and distributed on the belt so that two feet of yield can be discarded at each end of the row. Start fertilizer application a couple of feet in front of yield line.

(2) The fertilizer is weighed out and placed in small cloth bags stamped with treatment numbers. The bags are tagged with section and row numbers and boxed according to row and order of planting.

[3]The Engineering Department of the A. B. Farquhar Division, York, Penna., will furnish blueprint D422510 to any research institute interested in constructing attachments.

[4]The adjustable leveling device was designed by L. E. Barber, Superintendent of Agronomy Research Farm, Storrs Agricultural Experiment Station, University of Connecticut, Storrs, Conn.

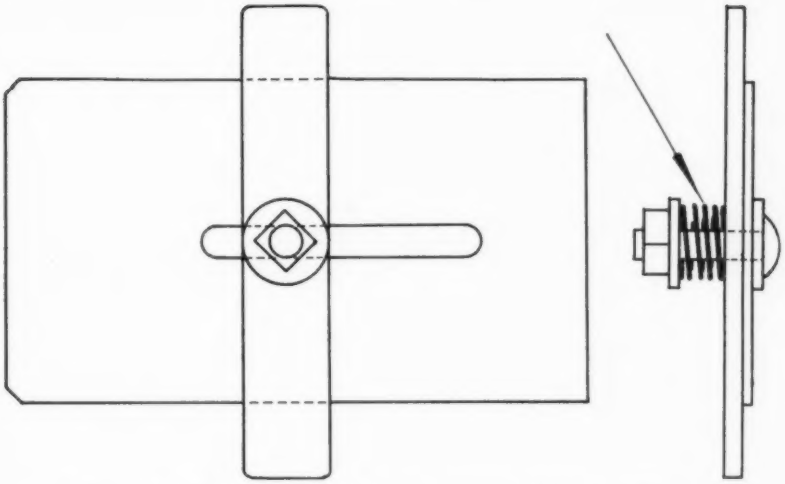

FIG. 3.—Adjustable leveling device for accurate fertilizer distribution.

(3) The point from which fertilizer is spread on the belt to the delivery gate should be determined finally at the location where the experiment is to be installed; it will vary with soil conditions, wear of sprockets, etc. Adjust for loss of motion or lag.

(4) Adjust spring tension on the leveling device so that the cross arm will stay in position while permitting quick adjustment to give uniform depth of fertilizer on the belt. The cross arm on the scraper will have to be adjusted for each different mixture or application rate. Reference marks can be made on the scraper.

(5) After the fertilizer is uniformly leveled on the belt, lift delivery gates to open position just as the planter is started very slowly.

SUMMARY

A fertilizer attachment for a potato planter which will distribute a weighed quantity of fertilizer for a given length of plot is described. The distributor distributes fertilizers or chemicals from a horizontal belt. By use of interchangeable sprockets four feet of belt travel will fertilize plots varying in length from a few feet up to 271 feet.

One of its most important features is the fact that the attachment permits accurate side-band placement of fertilizer on short plots.

The most recent improvement is the use of a quickly adjustable leveling device for leveling fertilizer to a uniform depth on the belt, and to insure that each foot of row receives the same amount of material. Techniques for using the attachment are given.

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Along with managing this large farming operation, "Tex" McCall finds time for an active role in Boy Scout, Rotary and Town Council work. He also serves as president of the Associated Industries of Maine, vice president of the Maine Polled Hereford Assoc., director of the National Assoc. of Manufacturers, vice president of the Aroostook Potato Growers, and officer in the family owned farm supply, frozen food and starch companies. Fishing and horse-back riding are his favorite leisure activities.

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BREAKING DORMANCY IN CUT SEED WITH 2 CHLOROETHANOL (CH_2ClCH_2OH) FOR GREENHOUSE TESTWORK[1]

SIMON BEZEMER[2]

Greenhouse testing for virus diseases of certified seed potatoes in Washington State has been part of the certification program since 1948 and is being conducted by the Washington State Department of Agriculture at the facilities of the North West Washington Experiment Station, Mount Vernon, Washington.

For a number of years, whole, singledrop potatoes were planted in the test plots and gassing was done by the standard method of a 72-hour exposure to 2 chloroethanol (CH_2ClCH_2OH) evaporation in a sealed room. However, a considerable increase in the number of fields and a corresponding number of samples made it necessary to economize on greenhouse space, Wherefore the single-eye-method of planting was introduced. This necessitated the cutting of seed shortly after the tubers were taken out of the gas room, with the relative health-hazard created by exudation of gas from the potatoes.

To forego this condition, we sought a method of gassing which would: (1) be done on cut seed, (2) be of shorter duration to speed up planting, (3) involve less handling of samples, and (4) would enable us to keep the remainder of the samples for several weeks for eventual replanting or for use as stock feed.

MATERIALS AND METHODS

Working under the assumption that direct contact of the chemical with the seedpieces should be more effective than contact through dilution by air, we prepared a solution of water and 2 chloroethanol at the rate of 30 cc of this material in one quart of water[3]. Single, suberized eyes were given a 10-minute dip in the solution and allowed to dry overnight. The 10-minute period was arbitrarily chosen as the minimum length of time in which any degree of penetration could be expected to take place. Only a few small, replicated plots were planted.

RESULTS

The results were so gratifying that the next year, 1958, we discarded the old gassing method and applied the new precedure to all our samples for greenhouse testing. The planting date was also moved up from early November to early October. The outcome was very satisfactory. Many plots had sprouts showing in seven days.

However, 1958 had an exceptionally long and dry summer, particularly west of the Cascade Range. (95 per cent of Washington seed potatoes are grown in the Lynden area of Whatcon County, the very North West corner of the United States). Potatoes generally matured early and we felt that this factor might have influenced the subsequent greenhouse test

[1]Received for publication December 17, 1959.
[2]Washington State Department of Agriculture, Seed Branch, Bellingham, Wash.

considerably. We did not know whether our system would have worked as smoothly, had there been a season with late growth and late maturity. The weather in 1959 was a season of this nature. The summer was cool, with many days of precipitation, which kept the plants green much later than usual.

Greenhouse planting was started September 23. Digging was in full swing and samples were collected almost simultaneously in order to get the greenhouse testing underway early. The dipping time was successively extended from 10 minutes to 15 and 20 minutes. The latter proved more satisfactory for the early work. Seedpieces began to show signs of life 7 days after planting. Most of the October and November plantings showed a little fasterresponse. Final readings on most of the plots were made on the average within 8 weeks.

Following is a summary of the procedure as it is now standardized in our program:

1. Store samples at approximately 70° F. for as long as is desired before seed is cut. This is the first step to discourage further dormancy.
2. Cut seed and spread to suberize under moderate temperature for 24 hours or less, depending on local conditions. It should not dehydrate to a point where it becomes soft or "spongy." Large mesh bags, less than half filled, do very nicely for this purpose.
3. Mix solution at the rate of 30 cc of 2 chloroethanol to 1 quart of water, preferably lukewarm. This will prevent seed from chilling in the dip. The use of a crock or lined container is advisable. Keep container covered at all times when not changing samples for dipping. If many samples are treated in one day, a few cc of the chemical may be added at intervals to compensate for evaporation. It is not advisable to use the same solution for more than one day, unless there is a way to keep it clean and sealed overnight.
4. Submerge samples in the solution for 20 minutes.
5. After removal from dip, spread seed to dry for 12 to 24 hours in the same manner as was done after cutting.
6. Plant. A thorough dusting of the seed with 5 per cent Captan has proved very effective for the prevention of seed piece decay.

Certain precautions must be observed when handling 2 chloroethanol:

1. Do not let the skin come in direct contact with the material.
2. Wear a respirator or gas mask whenever the chemical is being mixed and when samples are being dipped. It is not advisable to do this work in a tightly closed room.
3.. Do not expose other greenhouse plants to exudation of the gas from dipped seed; it will defoliate them.

[3]A guide to strength of solution was found in State of Calif. Bull. Vol. 34: 3.

NEWS AND REVIEWS

STUDIES SHOW VALUE OF FORCED AIR VENTILATION FOR POTATO STORAGES[1]

JAMES HUNTER[2]

Studies supported by potato tax funds have been underway at Aroostook Farm since 1955 to determine the effects of force air ventilation and circulation in potato storages. The experiments are set up to determine the effects of different ventilation patterns on shrinkage losses, specific gravity, control of bruise rots, breakdown from freezing injury and late blight. The study also concerns the efficiency of different types of equipment and control, the volume of air needed and how it should be supplied, and other factors involved in the design and construction of storage ventilation systems. The proportioning damper type of control system was installed at Aroostook Farm to provide accurate temperature control in the circulating air stream. Results of comparing various rates of air flow show that a low rate (in the through type system) may be less desirable from the standpoint of control of storage rots than no direct circulation at all.

GREAT VARIATIONS

Accurate control of temperature and moisture conditions in a storage is seldom possible when the conventional methods of gravity ventilation and circulation are used. Electric exhaust fans will provide ventilation and remove some heat and moisture. However, satisfactory air circulation control within the storage is seldom possible even with the exhaust fan system unless inlets are provided and a carefully designed circulation system is constructed.

The newer storages, which are well insulated and provided with a vapor seal, present even more of a problem than the older less well insulated and sealed storages unless the former are provided with adequate ventilation. Heat and moisture build up within the storage and cannot escape. Sprouting starts early and aggravates the problem. Forced air ventilation is a must under these conditions.

Some of the general benefits which may be derived from the forced air ventilation and circulation with an automatic control system are accurate uniform control of temperature, control of humidity conditions, and proper air circulation. Control of these environmental factors will result in control of bruise rots, storage rots and wet breakdown, reduce danger of storage frost, and control sprouting, and starch-sugar conversion.

The storage cycle has four principal phases. Control of bruise rots depends primarily on providing the proper conditions for healing of bruises. The recommended conditions for rapid healing are temperature from 50° to 70° F., and relative humidity of 90 to 95 per cent. Recent studies by Smith of Maine have shown that 70° F. and 85 per cent relative humidity at velocities of 6 to 8 feet per minute also promote rapid healing. The bruise healing period is the first phase of the storage cycle and should last from one to two weeks after the potatoes are placed in storage.

[1]Reprinted, with permission, from Maine Farm Research, Vol. 7, No. 2.
[2]Potato Handling Research Center, Presque Isle, Maine.

The second phase is the cooling and drying period. The potatoes should be constantly ventilated with air at the desired storage temperature (about 38° F.) and at a relative humidity of 80 to 85 per cent. If forced air ventilation is used, this period will be approximately a month. If forced air is not used the period may be extended to six weeks or more.

Step by Step

The third phase of the cycle is the holding period. The temperature should be held between 38° and 40° F. Below 38° potatoes rapidly acquire a noticably sweet taste. Above 40° F. sprouting will occur within a period of three to four months depending on variety, moisture conditions, and temperature. Intermittent vigorous circulation of air is essential during this period to assure accurate, even temperature control. Humidities should be high but the limiting point is when condensation occurs to such a degree that water drips onto the stored potatoes. Adequate insulation and air circulation will reduce condensation problems.

The final phase may be a short warming period prior to handling. Warming of the skins and outer layers of tuber flesh to 50° F. or more seems to reduce damage from tumbling and impact occurring in the handling operation.

The best control of bruise rots and breakdown from frost and blight was found to occur when one to one and one-half cubic feet of air per minute was used for each barrel of stored potatoes Weight loss from evaporation increased with increased rate of air flow, but usually did not exeed 4 per cent with a storage temperature of 38° to 40° F.

Another problem which has gained increasing attention this past season has been that of providing suitable storage conditions for holding Maine potatoes for a late spring and summer market. A forced air ventilation system with automatic controls will provide cooling as long as temperatures frequently drop below the holding temperature. Climatological data from the local weather station show that, on the average, some natural cooling is available until about May tenth.

There are two principle types of air distribution systems which have been used. The "through" type distribution system (Fig. 1), carries air beneath the storage bins where it flows directly up through the pile of stored potatoes. In the shell system (Fig. 2) air is not blown through the potatoes but flows around the bin in hollow wall spaces or inside a false wall.

Advantages of Each

The through system has the advantages of more rapid cooling or heating by the circulating air, probably maintains a more even temperature within the bin, and, when needed, has a better drying effect. It has the disadvantage of some increase in shrinkage losses. Somewhat more air may be required for best results. The shell system may require less air flow volume. Since the air does not flow directly around the potatoes, the higher humidity conditions in the interior of the bin will generally produce lower shrinkage losses. Temperature control however, is probably not as even and accurate, especially during the cooling period.

A combination of the shell and through systems may provide the

best solution. The through system would be used during the curing period and the cooling and drying period for better control of bruise rots and faster cooling and drying to prevent breakdown. After the holding temperature was reached, the system could be changed over to shell distribution by changing manual dampers. This would reduce shrinkage losses and possibly reduce operating costs slightly.

The heart of the automatic forced air installation is its control system

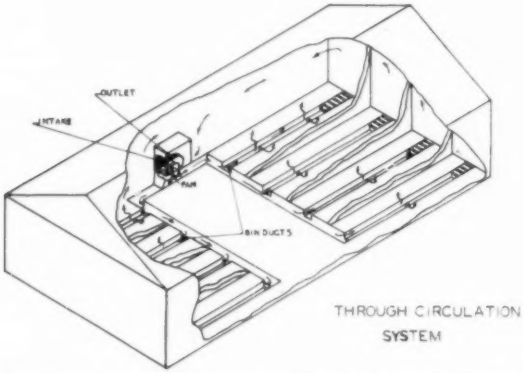

FIGURE 1.—In the through circulation system the air is carried beneath the storage bins and flows directly up through the piles of stored potatoes.

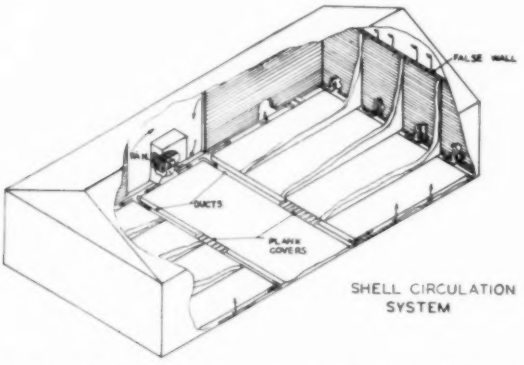

FIGURE 2.—In the shell circulation system the air flows around the storage bin in hollow wall spaces or inside a false wall.

which activates the fan motor and positions the temperature control damper. It has been found that manual control of a forced air system is seldom satisfactory. Adjustments must be made constantly to provide good temperature control, to provide the most efficient cooling, and to avoid danger of frost damage.

Total costs of ventilating equipment and installation vary with the

size of storage. Control costs now vary from about $175.00, for a system which requires some manual attention, to about $300.00 for a completely automatic control system with fire detection and other safety features. A reasonable cost for a fully automatic system might be $250.00.

Size Important Factor

Costs for fan and motor will vary from about 7¢ per barrel of storage capacity for a small storage (2,500 bbls.), down to less than 3¢ per barrel of capacity for a large storage (25,000 bbls.). Multiple systems are recommended for storages larger than 25,000 bbls. capacity, because of air distribution problems.

Costs for construction of distribution systems will be determined by labor costs, availability and costs of lumber and other materials, and by the size of the installation and whether it is new or old construction. These costs will range from 5¢ to 7¢ per barrel of storage capacity at current costs of labor and materials.

The total costs for a storage of 12,000 to 15,000 barrels capacity would vary from $1,500.00 to $1,800.00 or an investment of approximately 12¢ per barrel of storage capacity. If an interval timer is use to cut down fan operating time, operating costs can be reduced to approximately 1¢ per barrel per season. Electricity costs are assumed to be 3¢ to 5¢ per KWH.

IT PAYS TO BE HIDDEN HUNGER CONSCIOUS

Plants, like people, can suffer from hidden hunger — the period between the time they are in good health and in bad health. This is an insidious time because nothing *looks* wrong. The plant seems to be healthy — or certainly shows no signs of hunger. And then — almost suddenly, it seems — the plant crosses a point of no return as far as its finest yield and quality are concerned. Outward signs may never show — except in the yield. It's an insidious thing. Hidden Hunger! A problem requiring careful diagnosis and management that is always hunger conscious.

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What Thimet is, how it works

Thimet is a systemic insecticide. It actually enters and protects the entire plant. Thimet is supplied to potato growers in granular form and is applied in bands along the row, at planting. As the crop starts to grow, the roots pick up the Thimet and send it up to the leaves, making them toxic to insects. Thimet provides even, steady control right through the season. Thimet eliminates the need to "time" insecticide applications.

Insects controlled by Thimet

In many major potato areas, Thimet gives season-long control of aphids and leafhoppers; reduces flea beetle infestations. Because it stops leafhoppers, it helps control "purple top." In areas where late-season build-up of insects occurs, supplementary use of a conventional insecticide may be necessary.

Experiment Station tested

In Experiment Station tests, potatoes treated with Thimet consistently produced larger yields than unprotected potatoes. And, with Thimet, yields have often been higher than potatoes protected with conventional sprays.

No effect on quality

There are no residues in tubers at harvest, nor are chipping qualities affected when Thimet is used at recommended rates. Tests at Experiment Stations in Wisconsin and Ohio prove Thimet has no effect on flavor or chipping quality.

Rates

On heavy or upland soils, apply 30 lbs. of Thimet 10% Granular Insecticide; on sandy or light soils apply 25 lbs. Do not use Thimet on muck soils. Be sure to follow directions and precautions printed on the package.

Try Thimet 10% Granular Insecticide this season. Ask your County Agent and Insecticide Dealer about Thimet and the low-cost applicators that assure effective flow and placement. Write for free leaflet PE 5095. American Cyanamid Company, Agricultural Division, New York 20, New York. **THIMET* *is American Cyanamid Company's trademark for phorate.*

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